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L. O. HOWARD, Entomologist and Chief of Bureau.

HYDROCYANIC-ACID GAS AGAINST HOUSEHOLD INSECTS.

BY

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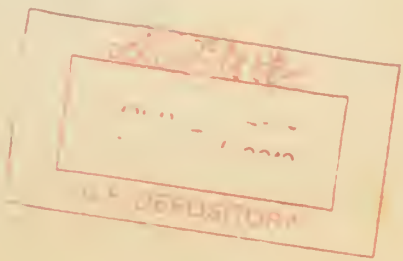

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HYDROCYANIC-ACID GAS AGAINST HOUSEHOLD INSECTS.

By L. O. HOWARD and C. H. POPENOE.

Hydrocyanic-acid gas is one of the most effective remedies known against various classes of insects. For more than 20 years it has been the principal means of controlling scale insects on citrus trees in California and is now in general use for the disinfection of all deciduous nursery stock and other plant material for shipment, and is one of the most effective methods of ridding greenhouses and cold frames of plant-lice, thrips, white flies, and various scale pests which infest plants grown under glass.[1] It has also become a standard remedy against the Mediterranean flour moth and other mill and grain insects.[2]

It has been fully demonstrated that this gas, which is very deadly to all forms of animal life, is, under proper precautions, an excellent remedy for household insects. Probably its first use for this purpose was in June of 1898, by Mr. C. L. Marlatt, of this bureau, against book lice in the residence of an employee of the Department of Agriculture, using the cyanid first at the ordinary strength employed on fruit trees, then double, and finally quadruple the strength. The book lice came from recently introduced leather-covered furniture, the covering of which was so tightly fastened as to be almost, if not quite, impervious to the gas, and the treatment was only partially successful. Another early use of this gas for household insects was in 1899 in San Francisco by the late Alexander Craw, then Chief Quarantine Officer of the Board of Horticulture. In this case it was used against bedbugs and in very small proportions. Two and one-half fluid ounces of commercial sulphuric acid and 2½ ounces 98 per cent cyanid of potassium were used in a house of several rooms, each containing about 2,250 cubic feet of space. The rooms were closed for two hours, then well aired. The operation was apparently successful.

[1] Refer to Circulars 37, 42, and 57 of the Bureau of Entomology and Farmers' Bulletin 172.

[2] Refer to Circular 112, Bureau of Entomology, by F. H. Chittenden.

Perfectly successful experiments were made during the summer of 1901 by Mr. W. R. Beattie, of the Department of Agriculture, and by Mr. A. H. Kirkland, at Boston, Mass. Mr. Beattie's experiments were against cockroaches and Mr. Kirkland's in one case against fleas and in other against clothes moths.

During the period between 1901 and 1907 hydrocyanic-acid gas was used in practical work by several members of the Bureau of Entomology, under the direction of Mr. Marlatt, many residences and public buildings, schools, churches, and stores being fumigated with practically uniform success. Indeed the efficiency shown by this gas in the control of household insects has led to its adoption as a standard remedy for these pests, and it has since been adopted for the destruction of insects affecting stored products, especially for the control of the Mediterranean flour moth (*Ephestia kuehniella* Zell.) in mills and warehouses. For this purpose it has proven extremely effective, having been used under the direction of agents of this bureau for the destruction of the flour moth in over 100 mills with excellent results.

Some entomologists recommend as a substitute for hydrocyanic-acid gas a substance which has been more or less effectively used, viz, carbon bisulphid. The great danger in the use of this latter substance, however, from its extreme inflammability and the explosiveness of its vapor when confined, renders it perhaps less available and more than counteracts the danger to human beings from the use of the hydrocyanic-acid gas. It has, moreover, been found that the hydrocyanic-acid gas is much more effective for the control of all groups of household insects, with the exception of the beetles, than is the other fumigant.

Entomologists have long noticed that insects vary greatly in their susceptibility to cyanid fumes. The ordinary killing bottle used in making collections contains cyanid of potassium covered with plaster of Paris, which the fumes of the cyanid penetrate. Certain weevils, and especially such weevils as Lixus and Sphenophorus and other hard-bodied forms, will frequently be left overnight in a cyanid bottle and recover after being removed. It has been noticed also that in greenhouses certain insects recover. The experience gained, however, indicates that the use of hydrocyanic-acid gas in houses is successful against cockroaches, bedbugs, fleas, clothes moths, ants, white ants, house flies, and other soft-bodied insects; and as these constitute the majority of the household pests, the use of the gas must now be considered a standard remedy. Moreover, rats and mice are also killed by its use, and it fortunately has the effect of first causing these animals to rush out from their holes into the open, so that the subsequent annoyance of dead mice in walls and under floorings is not experienced.

DIRECTIONS FOR USE.

Much experience indicates that in order to destroy the household insects mentioned, 1 fluid ounce of commercial sulphuric acid (about 1.84 sp. gr., = 66° Baumé) diluted with 3 fluid ounces of water, to increase the bulk of the liquid and insure complete chemical action, and 1 ounce of high-grade (98 per cent) cyanid of potassium, must be used for every 100 cubic feet of space. The formula per hundred cubic feet, therefore, is as follows:

Potassium cyanid (98 per cent)	avoirdupois ounce	1
Commercial sulphuric acid	fluid ounce	1
Water	fluid ounces	3

For loosely constructed frame houses the above amounts may be doubled per hundred cubic feet. The cyanid costs about 40 cents a pound and the sulphuric acid (thick or more sirupy commercial brand) about 4 cents a pound.

The purity of the cyanid of potash and sulphuric acid to the degree indicated is essential to the success of the fumigation. Potassium cyanid may be obtained in various "technical" grades, ranging between 40 per cent and 98 to 100 per cent actual cyanid, the remainder being an inert salt, usually sodium carbonate or sodium chlorid, which is of no value in fumigation and in the case of sodium chlorid is a positive detriment, as this substance, acted upon by sulphuric acid, produces hydrochloric acid, which decomposes the hydrocyanic-acid gas. In cases of extreme adulteration as much as 60 per cent of the fumigant may be decomposed in this manner, resulting in inferior effectiveness and tending to tarnish polished metal surfaces exposed to the gas. If chemically pure cyanid is used little tarnishing results.

Many of the manufacturers of cyanid place on the market a "so-called potassium cyanid" which consists of sodium cyanid adulterated with sodium chlorid. The chemically pure sodium cyanid liberates 33 per cent more hydrocyanic-acid gas than does the pure potassium cyanid, so that to avoid adulterated chemicals it is well to secure the so-called "133 per cent sodium cyanid" for best results. In the use of this chemical a correspondingly greater amount of the acid is necessary for the complete exhaustion of the cyanid.[1]

Before performing the operation the house must be vacated. It is not necessary to remove any of the furniture or household belongings unless of polished nickel or brass, which may tarnish a little. Liquid or moist foods, as milk, meats, or other larder supplies that are not dry and might absorb the gas, should be removed from the house. All fires should be put out; for while the gas will not burn under ordinary conditions, it is as well to take no risks.

[1] See "The Value of Sodium Cyanid for Fumigation Purposes," by R. S. Woglum (Bul 90, Pt. II, Bureau of Entomology, 1911). Mr. Woglum's studies of sodium cyanid have reference especially to its use in the fumigation of citrus orchards.

The cubic contents of each room on each floor should be carefully computed and a tabular statement, such as that given below, prepared, designating for each floor and the different rooms the capacity and the amount of water, acid, and cyanid needed.

Table designating rooms, capacity, and amounts of chemicals.

Floor.	Room.	Cubic feet.	Water.	Acid.	Cyanid.
			Fl. oz.	*Fl. oz.*	*Avd. oz.*
Fourth	Garret	[1] 7,000	210	70	70
Third	Front	2,800	84	28	28
	Middle	1,400	42	14	14
	Back	2,200	66	22	22
Second	Front	[1] 5,500	165	55	55
	Middle	2,200	66	22	22
	Back	2,000	60	20	20
First	Parlor	[1] 4,400	132	44	44
	Middle	2,400	72	24	24
	Dining	2,900	87	29	29
Basement	Servant's	1,200	36	12	12
	Hall	2,000	60	20	20
	Kitchen	1,800	54	18	18
Total		37,800	1,134	378	378

[1] The charges for these rooms should be halved and set off in two vessels.

The house is prepared for treatment by seeing that all the windows are closed and calked, if of loose construction, with wet paper or cotton batting tucked tightly into the crevices. Gummed paper strips are obtainable for this purpose, which may be pasted over the crevices in the doors and windows, making the room practically gas-tight. As the building must be aired by opening the windows from the outside, those selected to be opened should be examined to see that they pull down easily, and if too high to be reached from the ground should be provided with strong cords reaching to the ground that they may be easily opened from below. They should be opened before closing for the last time, in order to test the strength of the cord and should not be pasted up or calked. The fireplace flues in the different rooms should be stuffed with paper and the registers closed. Carpets and rugs, where possible, should be cleared away from the floor to prevent their being burned should the acid spatter or boil over.

For generators, stoneware or crockery jars having a capacity of 4 gallons are preferable and may be used with a charge of up to 3 pounds of cyanid. One of these vessels should be placed in each room, with the exception of large rooms requiring a charge of more than 3 pounds of cyanid, when the charge may be divided. One vessel will suffice for each 3,000 or 4,000 cubic feet, preferably the former amount. Under each of these vessels a rather thick carpeting of old newspapers should be placed, or a larger vessel, and care must be exercised to see that none of the vessels is cracked, on account of

the danger of breakage from the heat generated by the process. Deep vessels are more satisfactory for the experiment than the wash-basins often used, but the latter are always available and will serve the purpose. Deeper vessels give greater depth to the water and acid and accelerate the chemical action, and there is less danger of spattering. Whenever the room is of such size that much more than 3 pounds of cyanid must be employed for it, it is perhaps better to make two charges of half size for such room.

PROCESS OF FUMIGATION.

In the process of generating the gas the water may be measured in a glass beaker indicating ounces, or for convenience in a pint cup, and poured into the generators. The acid, measured in the same receptacle, is then slowly and gently poured into the water to avoid splashing or boiling. For all ordinary purposes 1 pint of the acid and 3 pints of water are sufficient for each pound of cyanid. *The acid should never be placed in the generators first*, as advised by some writers, since experience shows that this is dangerous, spattering being almost certain to follow. When the acid is poured into the water in the jar an ebullition of vapor sometimes arises. Considerable heat is also developed by the addition of the acid.

When the cyanid of potash is finally dropped into the combined acid and water mixture an ebullition or bubbling also takes place similar to that which is produced by a red-hot iron dipped into cold water. Next is given off the hydrocyanic-acid gas, the most poisonous gas in common use. It is colorless and has an odor which has been likened to that of peach kernels. If the fumes are inhaled they are almost certain to prove fatal; hence the necessity of extreme care and the advisability of two intelligent operators in this work. It is even advisable, especially when the first fumigation is undertaken, that one who has had experience with this method of fumigation be present to give directions. The odor is decidedly metallic, like that produced by striking two pieces of metal together, or of metal against stone.

The measuring and preparation of the water and acid in the fumigating jars should be undertaken in a room with a tile or concrete floor if possible, as the strong acid used is apt to injure wooden floors or carpets should spilling occur. The jars may then be distributed to the different rooms and a bag containing the requisite cyanid placed by the side of each.

The house is now in readiness to be fumigated. Coats and hats and everything needed outside must be removed, and preferably two persons should then go to the top of the house, taking different rooms on the same floor to expedite the process, and place the bags containing the cyanid gently into the vessels to receive them. The chemical

action will begin at once, but the gas will not rise to any extent for a few seconds or a quarter of a minute, and there is ample time to leave the room quickly without danger of breathing the gas. Having finished the garret or top floor, the operators should pass rapidly to the next, and so on to the basement, making their exit through the lower door to the street.

Hydrocyanic-acid gas is lighter than air, and consequently rises; therefore the operation must be begun at the top of the house.

The house should be locked from the outside and, if necessary, a warning sign put up to caution against entrance.

The preparation of the different rooms, getting their cubic contents, fixing the vessels, and preparing the charges, in a house of the size indicated in the table given above, will take from two to three hours, and this much time must be allowed for. The house should remain closed, for the gas to become fully generated and do its work, for 4 to 6 hours—preferably, however, and to get the greatest efficiency, 24 hours at least.

Better results are claimed for a warm temperature, say 70° F. or above, than in a temperature as low as 50° F. or below. Under 50° most insects become torpid and the effective action of the chemical will be diminished, especially in very low temperatures.

At the close of the operation the doors may be opened and the windows lowered or opened from the outside, and after an hour's airing the house may be entered if no strong odor of gas is detected, and opened up even more thoroughly, if possible, to allow a complete airing for several hours. The house should not be reinhabited until all traces of the odor of the gas have disappeared. This odor, as stated before, has been compared to that of peach kernels.

The contents of the generating jars should be poured into the sewer trap or disposed of in some place where they will not be a source of danger, and the jars thoroughly cleaned.

THE CYANID AND GAS A DEADLY POISON.

In the use of hydrocyanic-acid gas for household fumigation it must not be lost sight of for a single instant that one is dealing with one of the most poisonous substances known, and that the accidental eating of a small portion of cyanid will necessarily be fatal, and that the inhalation of a few breaths of the gas will asphyxiate, and, if rescue be not prompt, also have a fatal termination. It is much better, therefore, if fumigation be contemplated, to put the work in the hands of some one who has had experience, if such a person be available; if not, to consider carefully all the recommendations and precautions in this circular and become thoroughly familiarized with them before undertaking the experiment.

While the writer thus strongly emphasizes the dangerous and even fatal qualities of this gas when breathed by human beings, it is worthy of remark that in the thousands of operations which have been carried on with this gas in the course of its various applications in different parts of the world, only two cases of fatal accidents to human beings have been recorded. These were due to extreme carelessness in its use. In one case the operator went back into the house after having dropped the bags and closed the building for some time. The abundant experience which has been gained by the different members of the force of this office and many others in the fumigation of dwelling houses has demonstrated that all danger is easily overcome by care in conducting the operation, and in all the house-fumigation work which has been done during the last five years no accident has occurred, except in one or two instances the burning of rugs in attempting to set off charges in too small vessels and a case of headache where a few whiffs of much diluted gas had been accidentally breathed.

It follows, from what we have just said, that there may be danger from fumigating one house in a row of houses separated only by party walls, the other house being inhabited. Unnoticed cracks in a wall would admit the poisonous gas to the neighboring house. In such a case a householder must consult his neighbors. In isolated houses, however, with the precautions indicated, the operation will be a safe one. The fact that birds resting on the ridge of fumigated houses have been killed by the ascending fumes indicates also that where the house to be operated upon immediately adjoins a higher structure to which the gas may possibly gain entrance there may be some danger to the occupants of the higher structure.

It is undesirable to fumigate single apartments or rooms in buildings, and this should only be attempted when the whole building can be vacated during the operation. In case of contiguous houses of loose construction an arrangement should be made so that the adjoining houses also may be vacated during fumigation.

In handling the acid great care should be used in pouring it from the bottle and in putting it into the vessels to avoid spattering on the hands or face, since it will burn rapidly through the skin, and should it spatter into the eyes would cause serious inflammation, or if on the clothing it would burn a hole in the garment. Should a drop fly to the hands or face, bathe the part promptly and freely in water, and the same also for garments or the carpet. It is further desirable to have at hand a bottle of ammonia water to neutralize the acid should it spatter on clothing.

The handling of the dry cyanid is not accompanied by any danger if there be no open wound on the hand, but it is advisable to wear an old pair of gloves in breaking up the cyanid and putting it in

the sacks, these gloves to be afterwards burned. The fact that the cyanid has a superfical resemblance to sugar adds to the danger of keeping it about the premises, and it is much better to at once deeply bury or throw down the sewer trap any left-over cyanid.

SUMMARY OF METHOD.

The general directions for treatment may be briefly summarized as follows:

(1) Prepare tabular statement designating room capacity and amount of chemicals for each compartment, and secure the chemicals and vessels for generating the gas.

(2) Arrange for the opening of doors and windows from the outside at the conclusion of the fumigation, and close all registers, fireplaces, and other openings. Do necessary calking and remove carpets and rugs and moist food material and any metallic objects which are likely to be tarnished.

(3) Place the generating vessels in each room with a thick carpeting of old newspapers under each.

(4) Break up the cyanid out of doors and place it in thin paper sacks containing a pound or a half pound each, suited to the amounts to be used in the different rooms.

(5) Measure into each of the generating jars the proper amount of water, and afterwards add the acid slowly in the proper amount to each of the jars.

(6) Take the cyanid in bags in a basket and place the bags to the proper amount alongside of the generating jars in each room.

(7) Start at the top of the house and place the cyanid gently, so as not to spatter, into each jar, and quickly leave the room. As soon as the upper floor is finished go to the next lower, and pass in this manner from floor to floor until the basement is reached and exit is made through the lower door. If two persons work together in this operation they should both be on the same floor together, taking different rooms.

(8) The following day, or after the completion of the fumigation, open the windows and doors from the outside, and let the house ventilate for an hour before entering it.

(9) After the house is thoroughly ventilated and the odor of the gas has disappeared, the jars should be emptied in a safe place, preferably through the sewer trap, and thoroughly and repeatedly washed before being used for any household purpose.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *October 21, 1912.*

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